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Plastics

THE USE OF PLASTICS IN HIGHWAY CONSTRUCTION

By

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Thank you for this opportunity to present the relationship of your plastic industry to the building of highways. Highways are designed by highway engineers and built by the highway construction industry, both of whom are well versed in the usual materials of highway construction. These are earth, aggregates, asphalts, Portland cements, metals, and timber products.

The use of plastics in highway construction is progressing but the progress is necessarily slow. The modern highway is involved more in public safety than any other type of structure. In addition it requires the spending of a great deal of public monies. This responsibility urges caution but at the same time requires the utilization to their utmost economy of all available materials. So as to place the highway picture in perspective, it might be well to look at the recommended budget for State highways alone in California only. This budget for the coming fiscal year is slightly in excess of $633 million of which $509 million will be spent on highway construction including rights of way.

In order to show how plastics can and do fit into the highway picture, it appears that an orderly presentation of the various components that go to make up the highway structure would be appropriate. It must be remembered that for a material to be used in highway construction it must (1) provide the desired

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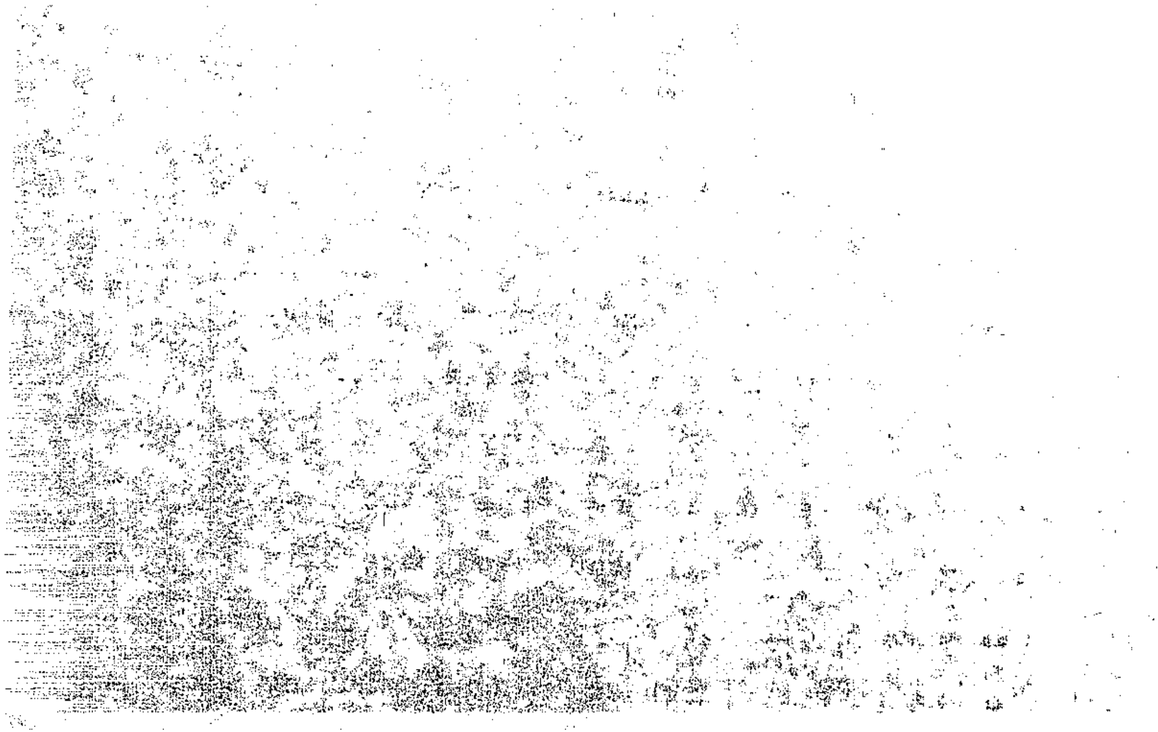
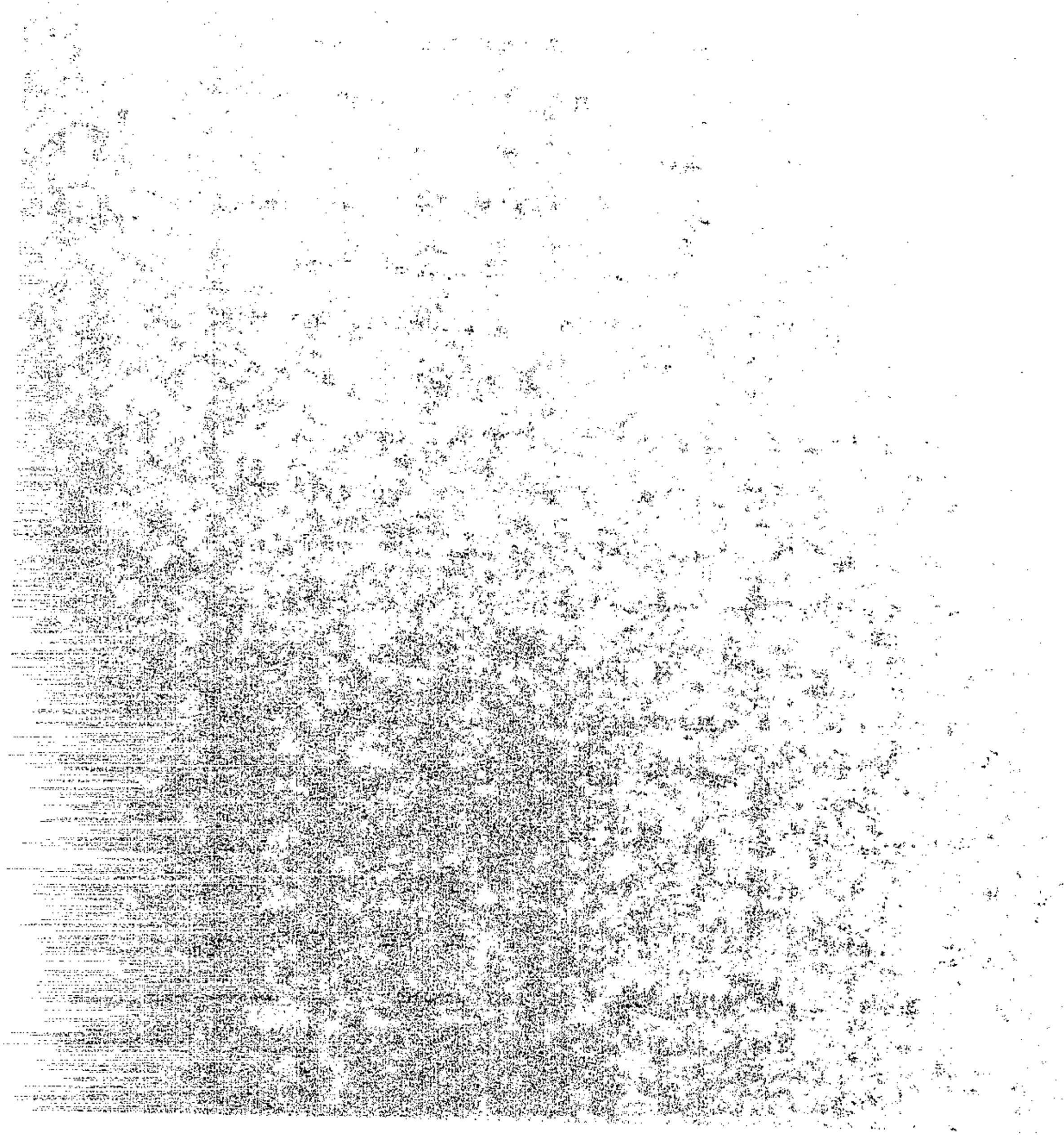
service economically and (2) it must be subject to control by a competitive specification.

After the rights of way have been obtained and the utilities cleared or rearranged, the roadway is ready for its foundation. One third of the cost of the highway is involved in this item. It primarily consists of moving large quantities of earth from the high spots which we call "cuts" and carefully placing the earth in the low spots for fills. This is the period when our underground drainage structures are placed. During this phase of highway construction little use is made of plastics. This is not because the use of plastics for culvert pipes and underdrains is not physically possible, but it is rather because plastics are not yet economically feasible for such use. This emphasizes the fact that in highway construction we first make a selection of the materials to be used from those that can physically do the job. Then the final selection is made on the basis of the material that will provide the most economical service.

The only area in drainage where plastics are now being used, and even then only occasionally, is where we encounter certain aggressive drainage waters. Here the use of polyvinyl liners in either concrete, clay or steel pipe is considered.

You might be interested in one rather large scale experiment that was made a few years ago by the State of Texas involving the use of plastic. As you may know, water is the prime enemy of the foundation engineer. If the water can be controlled within the embankment, the stability can be predicted with accuracy. Unfortunately water enters the fill both from the substrata and from the surface. The idea of this particular experiment therefore





was to wrap the entire earth fill in a sheet of plastic to control the water contents. The experiment was not a success because of various practical limitations. However, since that time the lining of reservoirs has been performed successfully and maybe this idea will yet find an application in the highway foundation field.

The next important phase of highway construction is the so-called structural section. This consists of carefully placed layers of stone aggregate, both cemented and uncemented, placed on top of the foundation so as to distribute the heavy traffic loads to the foundation. The final application on the structural section is the surface. This also is of aggregate, carefully graded and bound together either by asphalt or by Portland cement. Here again the major enemy to a long-life structural section is water. Some experimental use has been made of plastics both as a sheet to serve as an underseal and as a semi-liquid for sealing the surface cracks. None of these uses has gained much headway for highway purposes -- again primarily due to the economics of the materials.

Over 30% of the highway construction dollar presently goes into bridge structures. Whereas the major use of bridges formerly was to carry the highway across a body of water or perhaps a railroad or some other major physical obstruction, presently most of the bridges carry traffic across other vehicular traffic either as a separation or as an interchange structure with another roadway or as an elevated viaduct through a city. Bridges are using many plastic materials at present, and new uses seem to be developing every day.

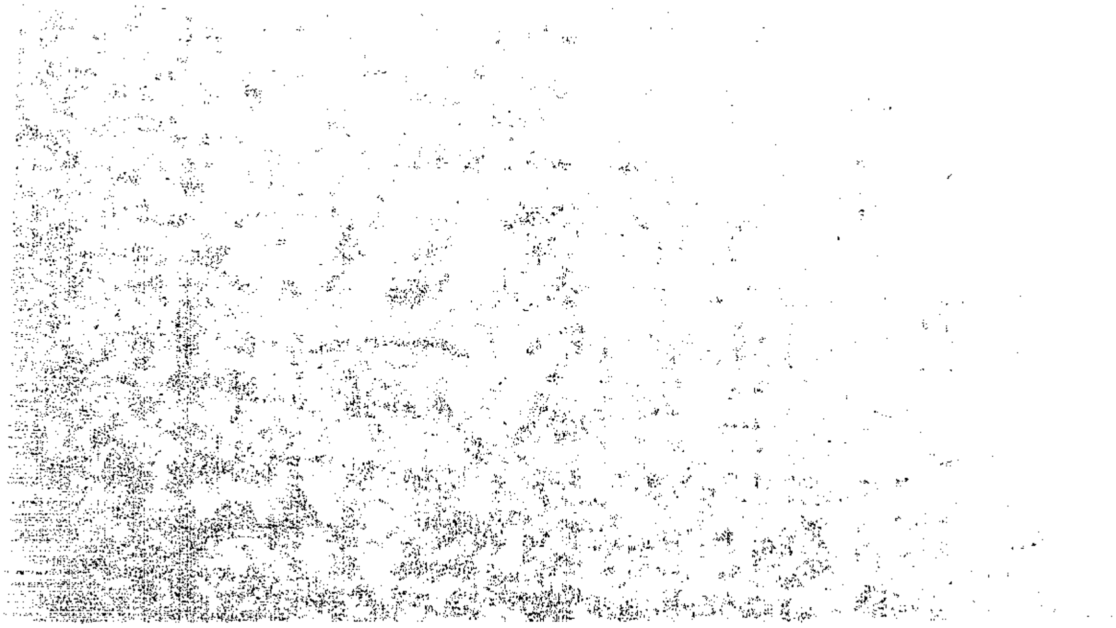
California's specifications, for instance, allow the use of polyvinyl chloride waterstops in practically all structures.

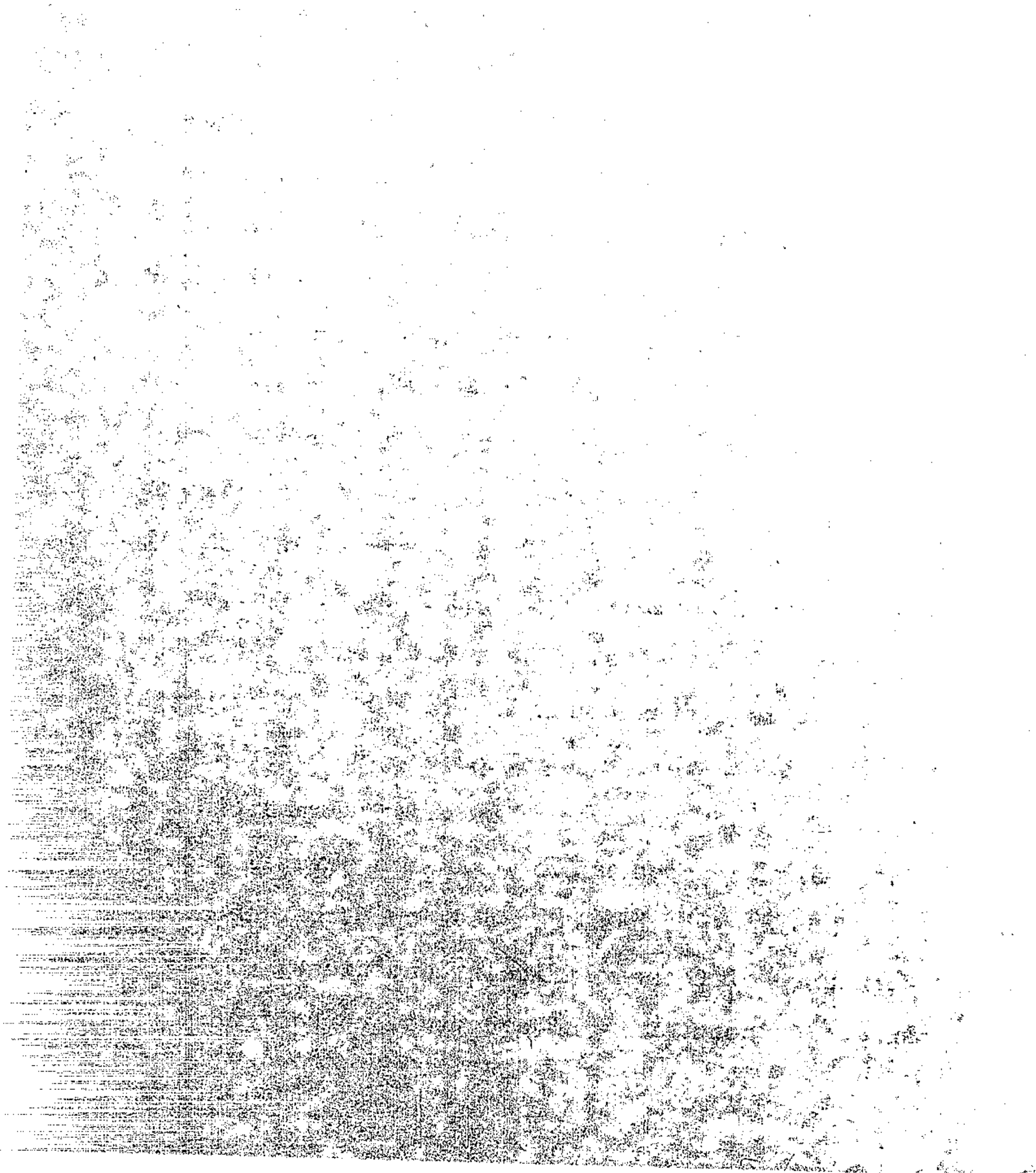
Such material has especially found its place in sealing open joints in the concrete decks of overcrossing structures. Neoprene bridge bearing pads now are used extensively as bearings of bridges. This is an excellent example of how a new idea has been applied to highway bridge construction and has resulted in a significant savings. Prior to about a year ago when elastomeric pads were first used to any extent, it was necessary that the concrete under the ends of the bridge members be finished to an exacting tolerance and that the steel plates involved in the bearing be machined to a close tolerance. At the moving expansion ends it was necessary that carefully fabricated and machined bearing rollers or rockers be furnished. Now all of this expensive hardware and finishing has been replaced by a single elastomeric pad which not only allows for rotation in various directions but also allows for the movement due to expansion and contraction.

One of the specialty uses of a synthetic material in bridge construction is at the ends where the bridge abuts into the approach roadways. Here, because of differential movements between the roadway and the bridge, there have been many abutment wall failures because of the excessive pressures caused by such differential movements. This is now taken care of by entering a piece of material that is relatively weak in compression so as to absorb the differential in movement while resisting the entrance of dirt from the roadway. One of the materials used for this purpose is a synthetic sponge-like plastic material. Some of the other areas in bridge work that might be worthwhile to explore are waterproofing membranes, downspouts, and of course further work in the corrosion protection of exposed steel work.

Slightly less than 10% of our over-all construction budget goes into traffic control and guidance systems and other miscellaneous structures, but it is in this field that the greatest use is made of plastic materials. For instance, many thousands of guide plates and posts have been and are being used each year. California Division of Highways alone uses approximately 250,000 guide plates each year. Before World War II wood was the prime material used for this purpose. Wood has the obvious drawback of rotting below the ground line and splintering badly during collision. Following the war metal plates on metal posts replaced the wood. Metal has and is still serving very well. However, there are three conditions of service along the highway that result in a short life of such standard materials as guide plates. One of these is in the desert where the markers are subjected to the sandblast action of the desert sands during high winds. Another is along the coast where the exposure to the direct sea breezes results in extremely rapid metal corrosion even of galvanized steel. The third problem involves traffic collision. If a marker post or plate is directly hit by traffic, it does not matter much what material it is made of. It is demolished. We have, however, a great many brushing type of accidents. The requirements for material to serve under this latter condition is one that has high impact strength but yet is flexible enough to bend out of the way during such collisions and then return to its original position.

After many years of cooperative work with several people of your industry, a plate at last has been developed that should serve well under all three of these difficult conditions. It is of thin sheet construction consisting of a central core of ABS





(cycolac) thermoplastic material with a polyvinyl fluoride or chloride surface film on each side of the core. The only problem still remaining is first cost. This, it is hoped, will be taken care of by time and volume.

With the exception of those few people who know exactly where they are going, our highway systems in general would be of little value if it were not for the control and directional signs. The California Division of Highways each year spends over $1.5 million for signs. Here again is a field where plastics are playing a more important part every day. Practically every sign that is built today contains some type of plastic material. There are still a few directional signs manufactured solely of porcelain enameled metal that are neither reflectorized nor lighted, but these are about the only types of signs presently constructed that do not contain some form of plastic material. Highway signs range from very simple designs containing a few plastic reflector buttons for night time visibility up to very complex flood lighted signs built in accordance with techniques developed primarily by the airplane industry. The reflex reflector is the work horse of the plastic items used by the Division of Highways. The Division alone uses from 200,000 to 300,000 of these each year, ranging in size from 1/2 inch through 3 inches in diameter and manufactured of acrylic material. The smaller sizes below one inch are used for night delineation of the message and various directional or warning signs while the larger buttons are used in conjunction with marker posts or other types of holders as warning delineators.

Highway specifications are very rigid concerning the reflection properties and sealing and weathering characteristics

of such reflectors and service experience over many years has been excellent. Our signing program also uses large quantities of various forms of material reflectorized by glass beads. In the past most of our reflex reflectors have been clear, yellow, and red. There is now a tendency to abandon the red as it is very difficult to find a red dye that will not cut the optical properties of the reflector down to a point where they are of little value on a high speed road. The yellows and oranges are replacing the red. Other colors also are coming into use such as blue. As a matter of fact, new signing and warning devices adopted as Federal Interstate standards are calling for a much wider use of colors than ever before. It is expected that as the use of these colors develops throughout the Interstate Highway System the colors themselves will relay a significant message even before the written message can be seen. The majority of the reflectorized material used on signs either as letters or as background material consist of glass beads held in a matrix and then covered with a clear plastic material. Some letters are made of reflectorized material encapsulated in an acrylic plastic so as to extend the life of the reflective material. Such a combination is also useful in some locations as a delineator button. The difference between this type of reflector button and a reflex reflector button is that the reflex reflector has relatively narrow beam and long sight distance, whereas the acrylic encapsulated reflectorized sheet has a wide angle but lesser visibility distance. The latter is useful on tight curves such as are used within interchange structures or areas.

Acrylic, cycolac (ABS), polyvinyls and polyesters reinforced with fiberglass about sum up the types of plastics so far used in our sign program. Probably the most serviceable plastic highway sign developed to date has been the polyester reinforced with fiberglass "Men and Equipment" sign. The message on these signs is printed on Kraft paper which is embedded in the fiberglass reinforced plastic material. It was developed in cooperation with your industry and has very nearly replaced the former metal signs insofar as California's highway maintenance work is concerned.

The life of metal "Men and Equipment" signs was limited due primarily to traffic and handling damage. Such signs are often struck by traffic and put up and taken down many times a day and thrown in the back of a truck where tools, etc. are intermixed with the sign. Under such practical working conditions the metal signs would become dented and scratched in short order. The new plastic sign stands up well and gives from four to five times the service life with the over-all cost to the State being reduced by more than 50%.

Another excellent example of the use of plastic materials in sign construction is a large sign recently developed by your industry using some of the honeycomb techniques developed by the aircraft industry. As our overhead directional signs become larger and larger as dictated by the speed and volume of present-day traffic, it has been necessary to develop lighter weight materials so as to reduce our costs in installing and supporting such signs. A first step in this program to achieve this lightness was to use aluminum honeycomb construction with porcelain enamel or plastic sheeting surfaces. Such signs are now being developed using a

honeycomb or foam core that is an inch to an inch and a half thick faced on each side with a plastic sheet completely impregnated with the desirable color. The outside sheets are polyester resin reinforced with fiberglass while the cores are either a treated paper honeycomb or a styrene foam.

Highway signals and lighting (both of the roadway and of signs) like most present day electrical equipment use a great deal of plastic material for items such as insulation, lenses, clear plastic covers for overhead sign lighting, conduit, etc.

There are several other special or experimental uses that have been made of plastics in highway construction and maintenance that have not generated a great deal of volume; however, they are interesting in their applications and illustrate some of the problems that can be solved by new materials.

Several high mountain roads are maintained open across the Sierra Nevadas and other mountains each winter. The plowing of these roads following a snow storm requires a means of identifying the edges of the road when it and the surrounding area is completely covered by snow. This is done by snow poles planted along the edge of the road before the snows start to fall. Wood or metal has always been used for this purpose. This past year an orange cycolac (ABS) pole has been used with good success. The pole is easy to handle, resistant to damage, and maintains color. The poles are about an inch in diameter and 5 to 10 feet long. Over-all cost is a factor not yet determined.

Corrugated structural plastic panels for use as headlight glare screens have been specified for a few of the new freeway structures in Los Angeles. Specifications on this material

were difficult to prepare so as to develop competition yet give adequate service insofar as weatherability, non-gloss surface, color and light transmission were concerned.

A very special use some of the eastern states are making of plastics involves the placing of a urathane foam insulation on the bottom side of reinforced concrete bridge decks. The purpose of this is to reduce the icing on top of the deck. If you have driven in the east you will have noticed that quite often the approach roadways are clear of ice, but as soon as you hit a bridge it is icy. This results in many accidents. The reason the approach roadway is not covered with ice is because of the insulation value of the underlying foundation, so on the bridge the urethane foam has been substituted for the earth under the roadway slab.

Another special use recently made of plastics concerned the acoustical treatment of a roadway tunnel. Residents at each end of the tunnel were finding it impossible to get any sleep at night because of the reverberations of the truck noises echoing out of each end of the tunnel. The condition was corrected by placing a series of baffles made of foam plastic material at each end of the tunnel and thus dampening the sound to a tolerable level.

A great deal of dynamic testing of guard rails and median barriers has been performed by the California Division of Highways. The results of this study have been the development of two designs, one utilizing cable with chain link fencing as a flexible barrier and the other utilizing metal beam and timber posts as a more or less rigid barrier. Recently a cooperative

project sponsored in part by your organization was undertaken so as to develop a median barrier somewhat similar to the metal beam on timber post blocked-out barrier, developed by the above program, using a fiberglass reinforced plastic as the blocked-out beam. This project has not been entirely completed; however, it is a good illustration of breadth of possible uses of plastics in highway construction.

This paper has not touched on the use of plastics in both paints and adhesives as this field is too highly specialized to cover in this type of presentation. However, the Division of Highways at present is either using or has experimental work underway on practically all newly developed paint systems using plastic materials, and in addition has been a pioneer in the development of the epoxy resin glues. Our greatest use of these materials has been in concrete bridge repair work and special uses such as the non-skid treatment of steel bridge decks and expansion joints. In addition, no mention has been made of plastic water pipe as its use has become routine.

In its opening, this paper touched briefly on the difficulty of preparing specifications for the use of plastic materials in highway construction. It is essential in public works that specifications be completely objective while at the same time they must be as broad as possible so as to promote as much competent competition as can be developed. The State Highway agencies are also faced with the fact that such specifications cannot be those of the interested industry.

In closing, therefore, it is urged that you as individuals and as a society work closely with an established material specification agency such as the American Society of Testing Materials or the American Association of State Highway Officials when you are developing specifications for the use of the highway industry.